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A Mechanism Showing a Remarkable Correlation Between Structure and Function in Connection With the Nursing Reflex in the Young Mammal.[1]

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IN THE ADULT MAMMAL four nerves are concerned with the innervation of the tongue, namely, the trigeminus, the facialis, the glossopharyngeus, and the hypoglossus. There is no little disagreement as to the rôle each of these nerves plays, especially with reference to the sense of taste. While seeking, if possible, to clear up some of the doubtful points, the present writer discovered a mechanism in the young rat and guinea pig which shows a remarkable correlation between structure and function in connection with the nursing reflex.

The material consists of a series of rat and guinea-pig embryos and fetuses, ranging in size from 13 mm. to five days after birth. The technique employed involved two well-known neurological methods. The first is a slightly modified form of the Bielchowski-Paton method, employing silver nitrate impregnation, followed by development with hydrochinone, dehydrating in alcohol, embedding in paraffin, and counter-staining of the sections with gold chloride. The second method used was the Ranson-Huber pyridine process, after decalcification in nitric acid. Both methods result in a differential staining of the nerve fibers so that there is visible a distinct contrast between them and other tissues.

In embryos of both the rat (13 and 23 mm.) and of the guinea pig (15 mm.) it was found that the posterior third of the upper

1. This is a portion of a paper entitled *"The Innervation of the Tongue,"* read at the fifth annual meeting of the American Society of Mammalogists, in Philadelphia, May 15, 1923. See *The Journal of Mammalogy,* vol. 4, No. 3, August, 1923, page 206.

surface of the tongue is innervated by a branch of the glossopharyngeus which passes posteriorly over, *i. e., dorsal to,* the cornu minus of the hyoid and ultimately reaches the distal extremity of the petrosal ganglion. It is clear, therefore, that the posterior third of the tongue in both the rat and the guinea pig is innervated by fibers which are a part of the glossopharyngeus. (See Plate XXIV, *G* and *g.*)

In the same specimens the anterior two-thirds or so of the tongue is innervated on either side by a well-defined trunk which passes posteriorly out of the root of the tongue and extends beneath, *i. e.,* ventral to, the cornu minus of the hyoid near its distal extremity, to the distal end of the petrosal ganglion, where this bundle of fibers divides into two approximately equal roots, one of which passes directly through this ganglion and ends in the motor area of the myelencephalon posterior to the ninth and tenth roots, and hence is to be recognized as the hypoglossus, or twelfth cranial nerve. (See Plate XXIV, *H.*) The second branch of this nerve trunk from the anterior two-thirds of the tongue leaves the main line at the level of the petrosal ganglion and pursues a course somewhat more caudad than the hypoglossus proper and ends in the ganglion of the *first cervical,* or the first of the spinal cord series. (See Plate XXVI, *Ci.*) The importance and significance of this fact will be considered presently.

Reverting to the trigeminus and facial nerves in relation to the tongue in these embryos, it was discovered that neither the lingual branch of the former nor the chorda tympani branch of the latter could be made out within the tongue in my preparations. If, as seems probable, they supply the innervation to the gustatory organs on the anterior two-thirds of the tongue in the adult, it is clear from these preparations that in these stages they have either not reached their terminations or are so insufficiently developed as to be indistinguishable. Since, however, as I have shown elsewhere,[2] the gustatory organs do not appear on the distal portion of the tongue until much later than these stages under consideration, I believe it is a fair inference that these special afferent fibers have not yet developed. At the very least, it must be admitted that they are playing a very minor rôle at this time, when both the glossopharyngeal and hypoglossal innervations of the tongue are well developed. This is a fact of striking significance.

2. "The Correlation between Structure and Function in the Development of the Special Senses of the White Rat," 1917, p. 57. Oklahoma University Studies No. 8.

The connection of the hypoglossus with the sensory portion of the first cervical is a fact of particular interest and importance, for it is clear that at birth the young rat must use his tongue for two purposes. First, it is a prehensile organ with a delicate tactile sense, by means of which the young rat feels for, discovers, and grasps the mother's nipple in order to obtain its nourishment. The posterior part of the tongue, supplied by the glossopharyngeus, on the other hand, is that portion of the tongue that will be washed by the milk stream when nursing, and so it is the seat of gustation in this early period. In short, the anatomical apparatus here described is clearly a demonstration of a strict correlation between structure and function—the anterior portion of the tongue in the nursling needs a tactile mechanism in order that the young rat may find its nipple and obtain food. The taste organs on the root of the tongue suffice to inform it of the flow of milk. This tactile mechanism is exactly provided for in the connection of the hypoglossal trunk with the first cervical ganglion. The hypoglossus (*wholly a motor nerve*) supplies the motor apparatus which governs the prehension displayed by the young rat's tongue; the first cervical supplies the afferent or sensory part of the reflex arc, which is concerned in the extraction of milk from the mother's nipple.

As I have shown in another place,[3] the gustatory organs over the anterior two-thirds of the tongue do not become functional until between the fifth and ninth days after birth, *i. e.*, not until the young rat is ready to begin nibbling at solid food. The sensory mechanism for gustation hence is much later in developing in this region than is the tactile apparatus, which must function much earlier. It would be hard to find a clearer or better illustration of the correlation between a structural mechanism and its function than this here described.

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3. "The Correlation Between Structure and Function in the Development of the Special Senses of the White Rat," 1917, p. 57. Oklahoma University Studies No. 8.

EXPLANATION OF PLATE XXIV.

Diagrammatic representation of the innervation of the tongue in the mammalian embryo (rat) of 13 mm. length. The ganglia connected with the cranial nerves, as well as the glossopharyngeus and hypoglossus nerves, are shown as projected upon a parasagittal section of the brain and the cervical portion of the spinal cord.

5, 7, 9, 10, represent the ganglia of the corresponding cranial nerves; *G,* nervus glossopharyngeus; *H,* nervus hypoglossus; *Ci,* sensory trunk of the first cervical nerve which joins the hypoglossal; *g,* gustatory area of the tongue; *t,* tactile area of the tongue; *h,* cornu minus of the hyoid.

PLATE XXIV.